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HONOLULU LA JOLLA MONTEREY TIBURON

REPORT OF ACTIVITIES March-April 1988

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COASTAL FISHERIES RESOURCES DIVISION

La Jolla, California

COMMERCIAL AND RECREATIONAL FISHERIES RESEARCH FOR MANAGEMENT

Improvements in the U.S. Tuna Industry During 1987 Reported

In their annual update of U.S. tuna industry trade statistics Industry Economist Samuel F. Herrick, Jr., Fishery Biologist Wesley Parks, and Pat Donley of the Southwest Region report that U.S. cannery receipts[1] of domestically caught and imported albacore (white meat) and tropical (light meat) tunas (skipjack, yellowfin, blackfin, bluefin, and bigeye tuna) continued to rise in 1987, reaching 532,704 short tons (tons), an increase of 2% from 1986. Deliveries by domestic vessels to U.S. canneries totaled 253,936 tons, up 12% from 1986, while imports of raw tuna fell 6% to 278,768 tons. The total pack of canned tuna by U.S. processors reached 33.6 million standard cases,[2] up 3% from 1986.

Seventy-two U.S. tropical tuna purse seiners, with an overall carrying capacity of 77,677 tons, made at least one fishing trip during 1987: a decrease of one vessel and a 4% reduction in carrying capacity from 1986. More vessels operated in the eastern Pacific than in the western Pacific during the year. Despite the reduction in fleet size, receipts of domestically caught, light-meat tuna totaled 251,100 tons in 1987, 12% above receipts for 1986. This total comprised 87,315 tons of skipjack tuna and 163,457 tons of yellowfin tuna (includes bigeye, bluefin and blackfin tuna), a 4% drop in skipjack deliveries and a 27% increase in yellowfin deliveries from 1986.

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[1]Cannery receipts include only tuna destined for U.S. canneries. Cannery receipts exclude U.S.-caught tuna landed at foreign sites, U.S.-caught tuna landed at U.S. sites that is destined for foreign canneries, U.S.-caught tuna destined for the fresh- fish market, tuna imported as flakes, imported tuna not fit for human consumption, and imported "sushi" grade tuna.

[2]A standard case consists of 48, 6.5-ounce cans or 19.5 pounds.

Imports of light meat tuna decreased 4% in 1987, falling to 177,407 tons. Imports of yellowfin amounted to 82,349 tons, up 4% from 1986. Skipjack made up the balance of light meat imports decreasing 9% from 1986. The total cannery supply of raw, light-meat tuna (domestic deliveries plus imports) for 1987 was up 5% from 1986, and was 4% above the 1983-86 annual average.

Contract prices for domestically caught, light-meat tuna delivered to U.S. canneries increased dramatically during 1987. The price of skipjack tuna 7.5 pounds and greater went from a low of $685 at the beginning of the year to $1,000 at year end. The contract price for 20 pounds and greater yellowfin tuna increased from $765 to $1,125.

In the U.S., skipjack, yellowfin, bigeye, and bluefin tuna are collectively canned as light-meat tuna. The 6.5-ounce can of chunk style, light-meat tuna in water has in recent years been the most popular tuna product consumed in the U.S. The domestic pack of all light-meat products totaled 26.4 million standard cases in 1987, a 7% increase from 1986.

Wholesale list prices for canned light-meat tuna also increased during 1987. Prices for advertised-label, light-meat tuna canned in water ranged from $42.45 to $45.00 per case at the close of 1987, up 4% to 24% from the first quarter. Private-label, light- meat prices at year end were $29.00 to $31.50 a case, up 19% to 26%.

Albacore is the only species that may be canned as white-meat tuna in the U.S. The volume of domestically caught albacore delivered to U.S. canneries in 1987 totaled 2,836 tons, 20% less than the volume in 1986. Imports of raw albacore totaled 101,361 tons in 1987, a 10% decrease from 1986, and accounted for 97% of the total cannery supply of albacore, the same as in 1986. The total cannery supply of raw albacore in 1987 was 10% below the 1986 level, and 2% above the 1983-1986 average. The domestic pack of white-meat tuna for 1987 amounted to 7.2 million standard cases, down 11% from 1986.

For the first time in recent years, the volume of canned tuna imports declined. Total canned imports were 10.8 million standard cases in 1987, a decrease of 11% from 1986. Imports

were dominated by tuna packed in water, which is subject to a much lower import duty than tuna packed in oil. When canned imports were combined with U.S. production, the total addition to U.S. canned supplies in 1986 was 44.4 million standard cases, less than a 1% decrease from 1986.

Worldwide, the demand for canned tuna, and hence raw tuna, was up during 1987, while harvests were down. This contributed to the increases in production, processing, and prices within the U.S. tuna industry described above. Production of light-meat tuna, particularly from the Atlantic and Indian Oceans, was down, creating tight supplies in a strong global market and as a result higher prices at the ex-vessel level. On the other hand, the U.S. fleet, which fished almost exclusively in the Pacific, experienced improved landings, and therefore a significant increase in earnings. Although these circumstances meant U.S. canners paid more for raw tuna, they also faced less competition from imports of canned tuna which translated into increased demand and higher prices for domestically packed tuna. Competition from foreign processors eased in 1987 as the dollar weakened against foreign currencies, and European markets for canned tuna expanded. Much of the foreign-processed and foreign- caught raw tuna was diverted to European markets because the European tuna industry, which is much more vulnerable to the shortfall in raw tuna production from the Atlantic and Indian Oceans, was unable to completely satisfy growth in demand for canned tuna. (S. Herrick, FTS 893-7111)

Economics Survey of Recreational Anglers Planned for Southern California

Beginning later this summer, staff of the National Marine Fisheries Service will be sponsoring a year-long survey of recreational anglers in southern California. The survey results will be used to estimate the economic value associated with specific modes, target species and geographic subareas within the fishery; to predict how this value is affected by changes in the quality of the recreational fishery experience (as precipitated by oil spills, water pollution, and the like); and to predict how the profound demographic changes, which are expected in southern California over the next 10-20 years, will affect the demand for fishing.

To acquaint industry and government representatives with the survey, Dan Huppert and Cynthia Thomson, Industry Economists, held a workshop at the Dana Point Resort. Among those in attendance were partyboat operators, fishing tackle manufacturers, environmental groups, angling clubs, and personnel from the California Department of Fish and Game and NMFS Southwest Region. Huppert and Thomson discussed how the proposed survey will contribute to currently available socioeconomic information on the fishery. They also elicited comments and suggestions regarding the sampling procedure and questionnaire content. As a result of the workshop, the questionnaire has been revised. Currently Huppert and Thomson are also evaluating alternative procedures for including non-coastal county residents in the sampling effort. (C. Thomson, FTS 893-7115)

Study of Sablefish Market Prices Completed

Dr. Dale Squires, Industry Economist at the Southwest Fisheries Center, and Dr. James Hastie, Industry Economist at the Northwest and Alaska Fisheries Center, have recently completed a study of the integration of the Tokyo central wholesale sablefish market and the ex-vessel fixed gear sablefish markets for Alaska and the Pacific coast. Squires and Hastie conducted the study to obtain a better understanding of how these markets interrelate. The study will be used in future economic analyses and it will be used in formulating policies.

Integrated markets are taken as those in which prices move interdependently. Looking at how prices vary over time and how they vary from market to market provides a means of determining the extent to which traders in two geographically separate markets are reacting to the same signals and are operating in essentially the same "market."

Following the Magnuson Fisheries Conservation and Management Act, fishermen from the Pacific coast and Alaska, particularly those using longlines and pots, have largely replaced the Japanese in harvesting sablefish. The subsequent growing reliance of Japanese sablefish markets on U.S. exports along with an expanding U.S. sablefish fleet suggests the possibility of a growing integration of the Japanese and U.S. ex-vessel markets. As U.S. production becomes more tightly interwoven with Japanese markets, the U.S. sablefish fleet will become more vulnerable to changes in Japanese market conditions. Changes in Japanese prices or the exchange rate have a much greater potential for

affecting U.S. fishermen today than previously. This likely increasing market integration of the Pacific coast and Alaska ex- vessel fixed gear and the Tokyo central wholesale market and increased economic dependence on the U.S. export of sablefish for both societies underscores the importance of better understanding the nature and extent of market integration.

The price linkages between the Tokyo central wholesale market and the Alaska and Pacific coast fixed gear ex-vessel markets were examined by regression analysis of monthly prices over a 6-year period, 1981 to 1986. The Pacific coast and Tokyo markets were found to be segmented--that is, changes in Tokyo market prices have no immediate or lagged effect on ex-vessel fixed gear Pacific coast prices. Instead, the Pacific coast price depends only upon its own previous values and local market conditions, indicating that the Pacific coast ex-vessel markets operate independently of the Japanese market.

In contrast, the analysis of price movements suggests that Alaska and Tokyo markets are closely integrated. Changes in Alaskan prices can be attributed to changes in Tokyo prices and past price differentials between the Tokyo and Alaskan markets. This indicates that market conditions in Tokyo are communicated effectively to the Alaskan market and influence prices there irrespective of local market conditions. In fact, previous local prices and localized market conditions contribute little to current Alaskan prices. These two markets are well integrated by price in this manner, although traders may fail to connect the two markets through commodity flows in the short run, particularly in the winter months.

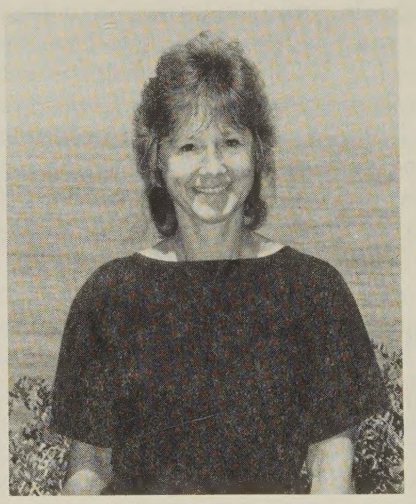
Although the Tokyo and Alaska markets are integrated by price over the long run, the two markets are not as closely linked over time periods as short as a month. A weaker short-run market integration does cause Tokyo market price changes to be generally reflected in the Alaska price level. Alaskan market responses to Tokyo price changes are symmetric, so that Alaskan responses to rising Tokyo market prices do not differ from responses to declining prices. The Alaska market price response to changes in the Tokyo market appears to peak after three months, and the impact of a Tokyo price change appears to die out after the fourth month. These market linkage models indicate how quickly and extensively shifting market conditions, or import policies, in Japan will reverberate throughout the Alaska market. (D. Squires, FTS 893-7113)

FISHERY-MARINE MAMMAL INTERACTIONS DIVISION

La Jolla, California

Research Ecologist from England Starts Work on Cetacean Ecology

On April 1, 1988, Christina Lockyer, Sea Mammal Research Unit, Cambridge, England, arrived in La Jolla to start a 12 month (at a minimum) sabbatical at the Center, where she will be collaborating with local scientists on cetacean ecology. Specifically, Lockyer will be working on 1) the determination of age of pilot whales with Dr. Al Myrick and Aleta Hohn, 2) the utility of satellite tags in monitoring the movements of free ranging pilot whales with personnel from Hubbs Marine Research Laboratory, and 3) the behavioral energetics of free ranging and captive dolphins.



Christina Lockyer

Lockyer has 18 years of post-graduate research experience in the field of cetacean biology. She has been a Senior Scientific Officer at the Sea Mammal Research Unit since 1972. Lockyer is considered an expert on the reproductive biology and feeding ecology of baleen whales and has contributed numerous papers in this area. Recently, she has become involved with conducting research on pilot whales that are hunted near and around the Faroese Islands. It

is this research responsibility that led Lockyer to negotiate with the then head of NMFS, Dr. William Evans, to come to La Jolla for a sabbatical where she could work with some of the leading experts in the world on how to age and track dolphins by using satellite tags.

While at the Center, Lockyer plans to learn how to utilize tetracycline marking to provide a ground truth for interpreting annuli in the teeth of pilot whales. The Center has collaborated with Sea World Inc. on a number of such projects over the last 5 years. In addition, Lockyer will try to secure additional funding to purchase up to three satellite tags for use in tracking free ranging pilot whales. At present, plans are being developed to use Sea World personnel and equpiment to catch up to three pilot whales during the winter months around Catalina Island. A similar study conducted on the east coast in 1987 was successful in providing movement data for up to 5 months on a satellite tagged pilot whale.

Lockyer's experience with the reproductive biology and general ecology of cetaceans should provide a unique opportunity for Center personnel to widen their understanding of marine mammal biology. In particular, Lockyer 's understanding of how research data feeds into the management regime (i.e., IWC) for large whales provides the opportunity for researchers at the Center to reevaluate how NMFS uses its research dollars to manage marine mammals affected by the tuna fishery in the eastern tropical Pacific and the gill net fisheries along the coast of California. (D. DeMaster, FTS 893-7165, C. Lockyer, FTS 893- 7090)

BIOLOGY PROGRAM

Tooth Characters Studied as Clues to Dolphin Stock Identification

Fishery Biologist Priscilla Akin has been studying geographic variation of 16 morphometric and other morphological differences in the teeth of spinner dolphins *(Stenella longirostris)* to determine whether the characters are associated with size of the animal, species-stock membership, or geographic location of collection.

In studying the tooth characters, Akin looked at 5 continuous measurements (such as tooth length) and 11 qualitative variables (such as paired incremental lines in the dentine). She conducted statistical tests, including tests for tooth differences based on stock membership, latitude and longitude of area of collection, and whether the animal was collected north or south of the equator. The principal component analyses combined factors of continuous variables with those of qualitative variables into components that were used as variables in further analyses. Discriminant analysis followed in which Akin used continuous variables alone and she used principal components as potentially discriminating variables.

Results showed that tooth differences were not associated with animal size, although significant differences were found in some tooth variables associated with stock membership, incremental changes in latitude, and whether the animal was collected north or south of the equator. The best discriminant function, which contained only tooth length, correctly classified 67% of northern and 78% of southern animals according to location of collection north or south of the equator.

The results of Akin's study have been published in Marine Mammal Science (1988, Vol. 4, No. 2, pp. 132-140). (P. Akin, FTS 893-7090)

FISHERY INDEPENDENT DATA PROGRAM

Types of Optimum Film Determined for Use during Marine Mammal Cruises

Hannah Bernard, Fishery Biologist, and Morgan Lynn, NOAA Corps, tested a new type of film in preparation for the marine mammal cruises to the eastern tropical Pacific in July. This new film (Plus-X aerecon II 3404) was recently released by the military.

During last year's cruise to the eastern tropical Pacific, the NOAA Ship *David Starr Jordan* was equipped with a helicopter, which carried a unique photographic remote sensing system. The system contained high-resolution cameras (KA-45 telephoto and KA- 62 wide angle lens military reconnaissance series) which were used to photograph schools of dolphins. The photographs will be used to calibrate the estimates of the shipboard observers.

After examining the photographs, the staff of the Photographic Remote Sensing Group were

able to determine which film and filter combinations produced the best results. They found that the black and white film with the highest resolution was 3412, although its use was restricted to very bright lighting. The film with the next highest resolution (3411) had some problems in the tropical environment; it was prone to sticking and jamming in the cameras. For that reason, Bernard and Lynn tested the new film (3404) to find a replacement for the 3411. They tested the film during a local flight aboard a chartered Partenavia aircraft in April and found that the resolution of the film was good, and that it had the attributes of non-problematic emulsion and thinner backing. They photographed a blue whale *(Balaenoptera musculus)* just off the Scripps Pier, and obtained their best imagery yet of local dolphin schools.

They also tested color infrared film for use in the Agiflite camera used for hand-held photography of small schools. Although the literature does not support the use of infrared film over water, the Map and Imagery Laboratory at the University of California, Santa Barbara, has produced evidence that this film is useful for photographing objects just below the water's surface. Both of these films will be used during the next marine mammal cruises departing in July. (H. Bernard, FTS 893-7166)

Birth Interval Model Developed for Marine Mammals

Dr. Jay Barlow, Operations Research Analyst, has constructed a birth interval model, which uses data of individually identifiable marine mammals. For every species of marine mammal that has been studied to date, there have been individuals that have been identifiable by means of natural marks or color patterns that are unique to that animal. Individual humpback whales can be identified from the distinctive color patterns on the undersides of their flukes. Similarly, bottlenose dolphins can be identified by the distinctive notches and scratches that appear on their dorsal fins. If individuals are seen repeatedly, which has occurred in many studies, this information can be used to estimate population size, migration patterns, natural mortality rates, ages at sexual maturation, and birth rates. Individual identification studies can thus provide valuable information that would be impossible to gather by any other non-lethal means.

Previous methods of using these data to estimate reproductive rates have been fraught with hidden pitfalls. Reproductive rates can be estimated as the inverse of the mean birth interval, which is one of the methods that had been tried previously. Birth intervals can be estimated from individual identification studies as the period of time between when a female is first seen in the company of a calf and the next time she is seen with a different calf. The pitfall of this method is that if a female is not seen every year (which is often the case), estimates of mean birth interval will be biased. A similar problem exists when estimating mean age at sexual maturation. If some known-age females are not seen the first time they have a calf, this will cause an overestimate in mean age at first birth.

Barlow's solution to these problems was to construct a new model of reproductive rates based on birth interval probabilities (a different probability for each possible birth interval) and first birth probabilities (a different probability for having a first birth at each possible age). These probabilities were estimated via a maximum likelihood algorithm that explicitly included a term for the probability of not being seen in a given year and the probability of surviving from one year to the next. Having estimated birth interval probabilities and first birth probabilities, Barlow used a simple Markov chain to combine these to give age specific fecundity rates (a more conventional way of reporting birth rates).

To test his new method for estimating birth rates, Barlow conducted a simulation study to imitate the sort of sampling that goes on from populations of individually identifiable animals. He specified mortality rates, probability of being seen, birth interval probabilities, and first birth probabilities for his imaginary population. He then took samples as if they were drawn randomly from such a population. From those random samples, he used his maximum likelihood algorithms to estimate the birth intervals probabilities and the first birth probabilities. These were used

Table 1. Estimated rates of population growth using the birth interval model applied in a simulation of an individual identification study. Coefficients of variation are given in percentages.

Simulated length of study	Number identified individuals	True growth rate	Estimated growth rate	C.V.
20 yr	200	0.998	0.997	0.4%
10 yr	100	0.998	0.993	1.9%
20 yr	200	1.025	1.025	0.2%

to calculate age-specific birth rates, which were combined with the "known" mortality rates to estimate a resulting population growth rate.

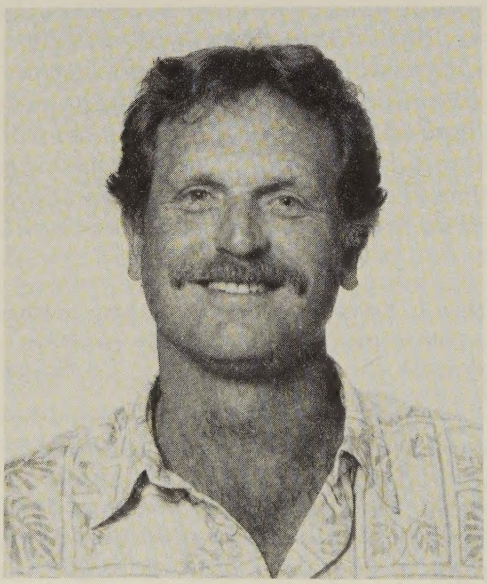
Results of the simulation study look very promising (Table 1). The birth interval model was able to estimate population growth rates very accurately and without apparent bias. The next step will be to combine the estimation of birth rates and mortality rates in the same simulation study. After that, Barlow hopes to apply his model to the more applied task of estimating birth rates based on resightings of individually identified animals from a real population. (J. Barlow, FTS 893-5167)

HONOLULU LABORATORY

Honolulu, Hawaii

Boehlert Selected as Director of Honolulu Laboratory

As of April 24, 1988, the Honolulu Laboratory of the Southwest Fisheries Center has a new Director. George W. Boehlert, Chief of the Laboratory's Insular Resources Investigation since 1983, replaces Richard S. Shomura. Shomura stepped down on March 1, 1988, after 15 years as Director to pursue several fishery- related projects before his planned retirement from Federal service this August.



George Boehlert

Since 1983, Boehlert has led the Laboratory's research on the physical and biological interactions in seamount ecosystems and the recruitment dynamics of island ecosystems. An extremely prolific writer, Boehlert has authored dozens of scientific publications on these topics as well as on the physiological responses of fishes to environmental changes and recruitment dynamics, reproduction, ageing, and growth of fishes.

Prior to joining the Laboratory, Boehlert was an associate professor with Oregon State University, 1979-83. He received his Ph.D. in marine biology from the University of California, San Diego, Scripps Institution of Oceanography in 1977.

MARINE MAMMALS AND ENDANGERED SPECIES PROGRAM

Quantitative Methods for Determining Optimum Sustainable Population Examined

Quantitative methods for determining optimum sustainable population (OSP) levels have recently been reviewed and compared by Tim Gerrodette, Fishery Biologist with the Honolulu Laboratory, and Douglas DeMaster, Chief of the Fishery-Marine Mammal Interactions Division at the La Jolla Laboratory. The OSP is a concept introduced by the U.S. Marine Mammal Protection Act of 1972, which specified that marine mammal populations should be maintained at an OSP level consistent with the "health and stability" of the whole ecosystem. Defining what is meant by OSP and determining whether a given marine mammal population is at an OSP level have been problems confronting the National Marine Fisheries Service ever since.

Gerrodette and DeMaster found that present methods for determining OSP fall into two general types: those that require an estimate of a population's maximum net productivity level (e.g., the back-calculation method) and those that do not (e.g., the dynamic response method). The two types of OSP determination differ in the data they require and in whether they determine OSP with respect to present or historical carrying capacity.

The two types of OSP determination were compared for *Eschrichtius robustus*, the gray whale. Using population estimates computed by Fishery Biologist Stephen Reilly of the La Jolla Laboratory, Gerrodette and DeMaster carried out a dynamic response analysis for the gray whale for the period 1967-80. The pattern of second-order regression coefficients indicated that in 1980 the gray whale population was in OSP range (Fig. 1). This conclusion agreed with an assessment based on Reilly's back-calculation estimate of carrying capacity for the gray whale in 1800. Because the two types of OSP determination were almost independent, their agreement greatly strengthened either single analysis.

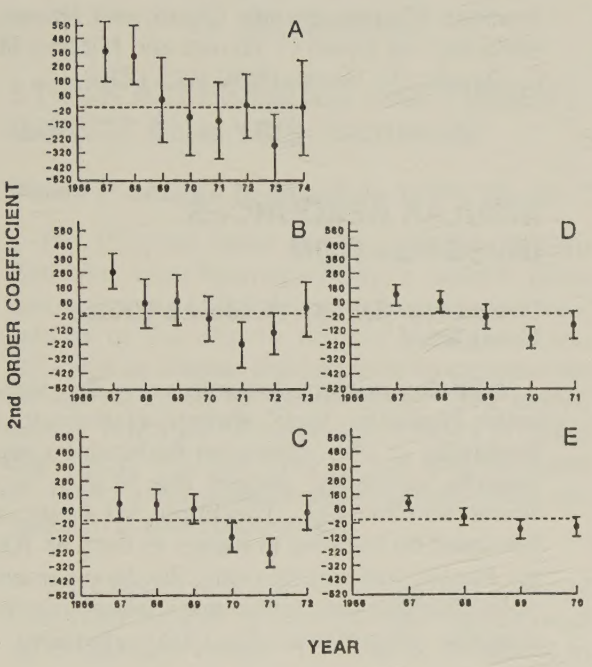


Figure 1.--Dynamic response analysis for the California gray whale, 1967-80. The second-order regression coefficient is plotted against the initial year in the sequence of censuses. The different panels plot coefficients against sequences of censuses of different lengths. (A) 6 yr, (B) 7 yr, (C) 8 yr, (D) 9 yr, and (E) 10 yr.

A distinction was also drawn between abundance and condition indexes used to monitor marine mammal populations. The former measures some aspect of the population related to actual numbers of animals (e.g., number of pups born). The latter measures some aspect of the population related to population size as a fraction of carrying capacity (e.g., pup mortality rate). Monitoring programs should be designed to include both abundance and condition indexes, because they reveal different aspects of changes in the population and its environment and both are involved in the definition of OSP. (T. Gerrodette (808) 943- 1224)

FISHERY MANAGEMENT RESEARCH PROGRAM

Koko Head Oceanographic Sampling Results for 1987 Reported

A brief report summarizing the Koko Head oceanographic sampling for 1987 was recently completed by Biological Technician (Fisheries) Russell Y. Ito. The report contains a description of the sampling procedures and graphs of the 1987 sea-surface temperatures plotted against a long-term average (1955-86) as shown in Figure 2.

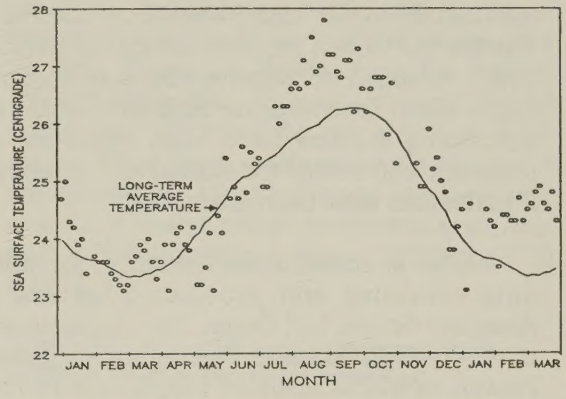

SEA SURFACE TEMPERATURE (CENTIGRADE)
LONG-TERM AVERAGE TEMPERATURE
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR
MONTH

Figure 2.--Koko Head sea-surface temperature, January 1987-March 1988.

Sea-surface temperatures in 1987 generally were higher than average and, in the first quarter of 1988, were considerably above average. Ito indicates that, as a result, 1988 will be a good test of two competing hypotheses on aku *(Katsuwonus pelamis)* availability: An availability estimate of large aku by Christofer H. Boggs, Fishery Biologist with the Pelagic Resources Investigation, that correlates aku availability with temperature changes, and a popular local hypothesis in which heavy mango blossoming foretells large aku. (R. Ito (808) 943-1210)

Economic Assessments of Small Boat Harbor Facilities Completed

Economic assessments of harbor improvements at Kahului, Maui, and at two sites on Oahu were recently completed by Samuel G. Pooley, Industry Economist, and submitted to the U.S.

Corps of Engineers, Pacific Ocean Division. The reports conclude a 3-year cooperative project that also assessed harbor improvements at Pohoiki, Hawaii. The results of the project will be released as an administrative report, currently being prepared by Pooley, on small boat fishing in Hawaii. (S. Pooley (808) 943-1216)

WPACFIN PROGRAM

Third Volume of Report Series Completed

The third volume in the report series "Fishery Statistics of the Western Pacific" was completed in March 1988, according to David C. Hamm, Program Manager of the Western Pacific Fishery Information Network (WPACFIN). This report series was created in 1986 to formally distribute summary fishery statistics to participating agencies in the Pacific, as part of WPACFIN's goal of helping meet the need for better fishery statistics in the Pacific. The WPACFIN was implemented by the SWFC in 1981. Through cooperative efforts of numerous Pacific island fisheries agencies, data collecting and processing systems have been improved significantly, and means for sharing and distributing fisheries data have been established.

Volume III contains descriptions of the fishery data collecting and processing systems for American Samoa and Guam, the Commonwealth of the Northern Mariana Islands, and the State of Hawaii, as well as summary fishery statistics for all these areas for the calendar years 1985 and 1986. Monthly and annual summary reports of weight and value by species are reported for the commercial landings for all areas. Creel survey summary reports for American Samoa and Guam include monthly and annual catch and effort statistics and species composition by fishing method. Also included are bar charts and line graphs showing landings of the major pelagic species, bottom fish, tunas, and other species and species groups of importance for fishery management. Additional 8-year time-series graphs are presented for important fishery statistics. A comprehensive presentation of summary fishery statistics for these four areas for 1985-86, Volume III contains 232 tables and 123 figures in over 350 pages. Volumes I and II contained similar information from 1979 through 1984 for all these areas except American Samoa, for which only 1982-84 data are available.

The information summarized in this report is used by fishery researchers, analysts, and managers as well as by the fishing industry throughout the Pacific area. This report series is the only distribution of its kind in the Pacific. The document is widely used by NMFS scientists, Western Pacific Regional Fishery Management Council (Council) staff, Fishery Management Plan Monitoring Teams, Council Advisory Panels, and by each of the four island agencies whose data are contained therein. It is also used by fishery offices in developing Pacific island nations as a reference and template for developing their own reporting capabilities.

Volume III is available as Honolulu Laboratory Administrative Report H-88-4, "Fishery Statistics of the Western Pacific: Volume III, American Samoa, Commonwealth of the Northern Mariana Islands, Guam, and Hawaii, 1985-86," by David C. Hamm and Michael M. C. Quach. (D. Hamm (808) 943-1214)

INSULAR RESOURCES INVESTIGATION

Deepwater Shrimp Research Cruise Completed

A 28-day research cruise to study the deepwater Hawaiian "ono" shrimp, *Heterocarpus laevigatus*, in the Hawaiian Archipelago was recently completed aboard the NOAA Ship *Townsend Cromwell*. This bright red shrimp is harvested by trapping in waters as deep as 700 m. For the past several years, the development potential of this shrimp resource has been of considerable interest to the local fishing industry.

To determine the distribution and abundance of the shrimp, 106 large pyramid-shaped shrimp traps were set at depths of 500-800 m around Laysan Island, French Frigate Shoals, Kauai, Oahu, and Hawaii, according to Chief Scientist Darryl Tagami. The shrimp caught were generally large, typically 28-57 g (1-2 oz) each. The mean catch rates for an overnight soak were 0.6 kg per trap-night at Laysan Island, 1.3 kg at French Frigate Shoals, 12.5 kg at Kauai, 4.3 kg at Oahu, and 4.7 kg at Hawaii. Peak abundance of shrimp was found between depths of 600 and 700 m. In addition, carapace length and sex data were collected on 7,351 shrimp.

This survey is part of a stock assessment program at the Honolulu Laboratory for deepwater shrimp in the Hawaiian Archipelago. The

information collected on this cruise will be useful to local shrimp fishermen and fishery managers.

Tagami was assisted on the cruise by Fishery Biologists Stephen V. Ralston and Paul M. Shiota, Biological Technician (Microbiology) Happy A. Williams, and Computer Programmer Wayne S. Higuchi.

PELAGIC FISHERY RESOURCES DIVISION

La Jolla, California

STOCK ASSESSMENT AND FISHERY IMPACT ANALYSIS PROGRAM

Movie Produced to Simulate TOPS Model

Drs. Elizabeth Vetter and Pierre Kleiber, Fishery Biologists, have been developing a model to simulate movement of dolphin schools and tuna purse-seiners in the eastern tropical Pacific and the collection of dolphin sighting data by scientific observers on board the purse-seiners. The model, named TOPS for "Tuna-vessel Observer Program Simulator," will be used to test and evaluate methods for using dolphin sightings data to estimate trends in dolphin abundance.

The model covers a 1200 nautical mile square of ocean and includes up to 3000 dolphin schools and up to 100 tuna vessels. The rules of movement in the model are simple. Dolphin movement is influenced by a habitat quality topography which can be set to move or can be held motionless. Dolphin schools tend to keep going the way they are going if the habitat is good and tend to reverse their direction if the habitat becomes worse. Movement of tuna vessels is influenced by each vessel's perception of dolphin abundance. That perception depends on the vessel's recent history of dolphin encounters and is colored by a "McGlade" coefficient which determines whether vessels are risk-takers or are more conservative in outlook.

To assist in visualizing the performance of the model, Kleiber and Vetter have produced an animated film with the help of Steve Lamont of the San Diego Supercomputer Center. The TOPS model was first ported to the Cray Supercomputer, and approximately 6000 frames of graphical output from the model were recorded on film. The movie clearly shows the dolphin schools aggregating in areas of good habitat quality and following the movement of those areas. When tuna vessels encounter clusters of dolphin schools, they tend to stay with them and, as a result, spend a disproportionate amount of time in high abundance areas. (P. Kleiber, FTS 893-7076)

1986 Results of Pacific International Billfish Angler Survey Compiled

Since 1969, the National Marine Fisheries Service has conducted an annual survey of billfish anglers throughout the Pacific and recently those in the Indian Ocean. Jim Squire, Fishery

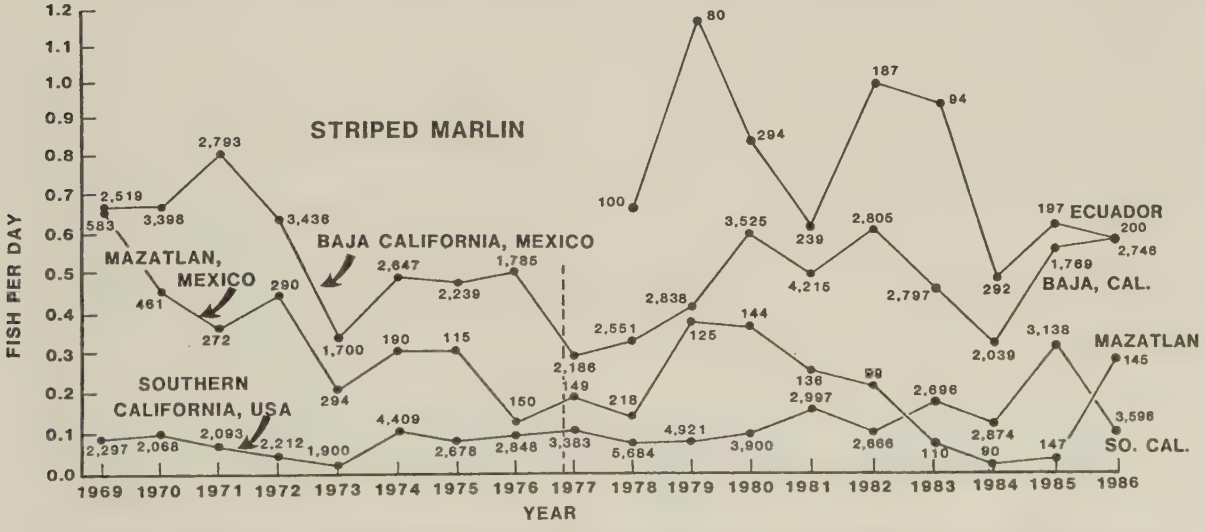


Figure 1. CPUE (number of fish/angler day) and number of respondents for striped marlin, 1969-1986.

Biologist responsible for conducting the survey, sends questionnaires to anglers requesting information about their catch and effort for that year. The survey is conducted in cooperation with the International Game Fish Association. The 1987 Pacific Billfish Angler Survey is now in progress, and the 1986 survey results have been compiled by Squire.

For 1986, Squire found that the total number of billfish fishing days reported by billfish anglers responding to the survey for the Pacific and Indian Oceans totaled 15,932 days, of which 13,711 of those days represented fishing in the Pacific Ocean. Anglers fishing in the Pacific reported catching 6,949 billfish; in the Indian

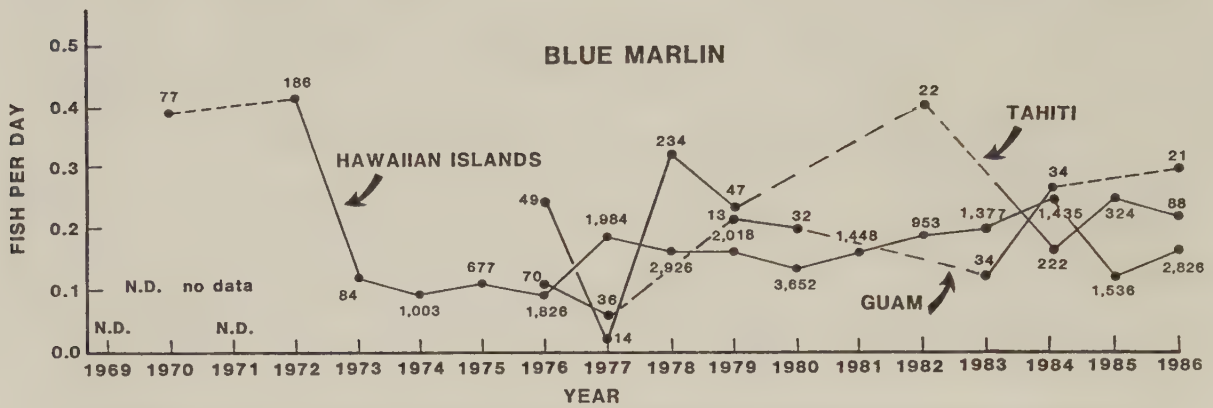


Figure 2. CPUE (number of fish/angler day) and number of respondents for blue marlin, 1969-1986

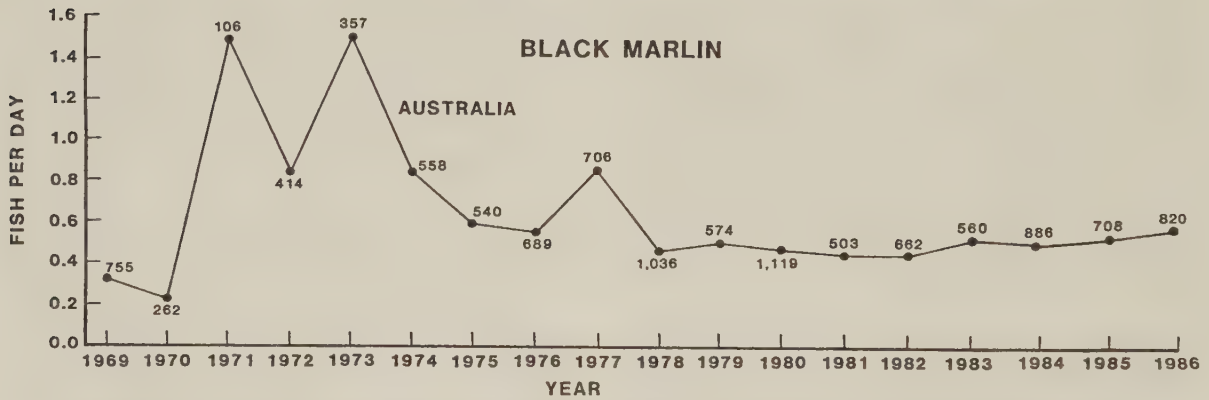


Figure 3. CPUE (number of fish/angler day) and number of respondents for black marlin, 1969-1986.

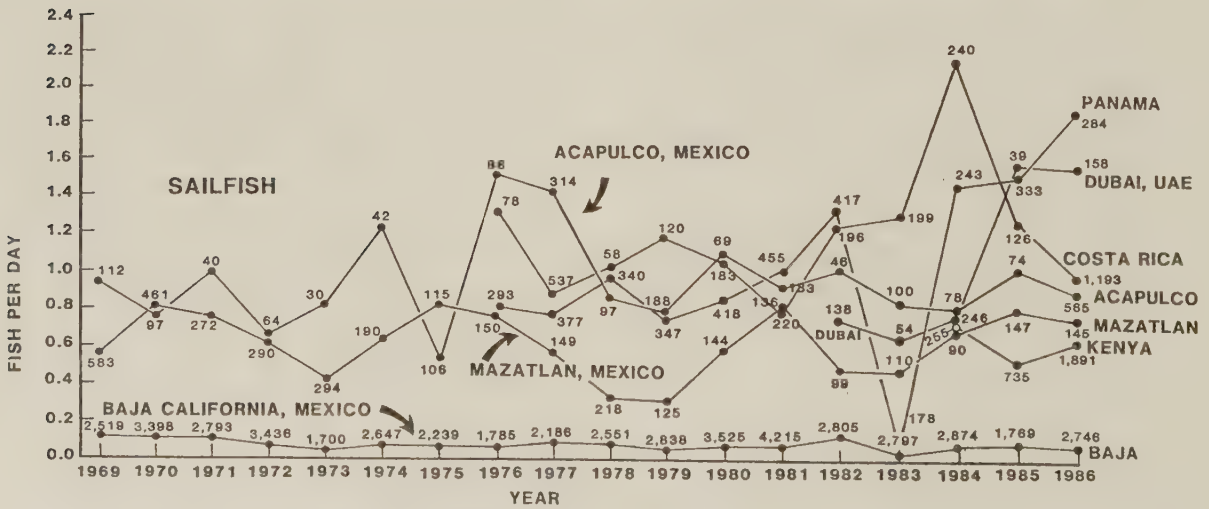


Figure 4. CPUE (number of fish/angler day) and number of respondents for sailfish, 1969-1986.

Ocean, anglers caught 1,473 billfish. The catch rate average for both the Pacific and Indian Oceans combined was 0.52 billfish per angler day (1.89 days per billfish). For the Pacific, the catch rate was 0.51 billfish per angler day (1.97 days per billfish) and for the Indian Ocean the rate was 0.66 billfish per angler day (1.51 days per billfish). The catch per angler day for 1986 in the Pacific was the same as recorded for 1985 (0.51 fish per angler day). Figures 1 through 4 give the catch per angler day in the Pacific and Indian Oceans for striped marlin *(Tetrapturus audax)*, blue marlin *(Makaira nigricans)*, black marlin *(Makaira indica)* and sailfish (Istiophorus platypterus). In comparing these figures to those from the early years of the survey (1969 to 1972), Squire found that the current catch rate is only slightly less than that observed 15 years ago.

Detailed results of the survey from 1969 to 1985 will be published in the Marine Fisheries Review in a special recreational fisheries issue, which is scheduled to appear in May 1988. (J. Squire, FTS 893-7072)

TIBURON LABORATORY

Tiburon, California

FISH COMMUNITIES INVESTIGATION

Cruise Investigates Ecology of Deep-Slope Groundfishes

Fishery Biologists Peter Adams and Wayne Samiere of the Fish Communities Investigation and Lt (jg) Kristie Miller, NOAA Corps, worked during a cruise of the NOAA ship *David Starr Jordan* to obtain information on the ecology of deep-slope groundfishes: dover sole *(Microstomus pacificus)*, sablefish *(Anoplopoma fimbria)*, shortspine thornyheads *(Sebastolobus alascanus)*, and longspine thornyheads *(S. altivelis)*. These species constitute 40% of the non-hake groundfish. Although knowledge of their ecology is essential to their management, little is known about the ecology of these deep-slope groundfishes. During the cruise, information about the deep-slope ecosystem was also collected.

Adams, Samiere, and Miller investigated several points raised by preliminary data collected during an earlier (1987) cruise. First, a depth-stratified series of stomach-samples from dover sole and sablefish--the principal targets of the fishery--were taken from young fish in shallow water, and from older fish in deeper water. Second, they took samples to consider whether the longspine thornyhead is an important prey of both the shortspine thornyhead and the sablefish. Finally, samples were taken to compare the diet of the dover sole with that of the deep-water sole *(Embassichthys bathybius)*. These two species are very similar externally, although they have distinctive gut morphologies. Samples collected are now being analyzed, but this is a slow process because the fauna other than the fishes is poorly documented. (P. Adams, FTS 556-0565)

First-Year Juvenile Rockfish Make Another Early Appearance in Northern Californian Nearshore Habitats

For the second consecutive year, young-of-the-year rockfishes, primarily blue rockfishes *(Sebastes mystinus)* and yellowtail *(S. flavidus)*,have appeared earlier than usual in northern Californian nearshore habitats. Investigation Leader Ted Hobson, with Fishery Biologists Tony Chess and Dan Howard, noted the occurrence of these fishes during the last week of April, the same time they were first seen last year. The late-April appearance of the 1987 year-class was noted at Mendocino (see March-April 1987 Report of Activities) to be the earliest recorded by the staff of the Groundfish Communities Investigation during 9 years of monitoring along the Mendocino coast. During most years the initial appearance of juveniles has been in June, and prior to last year the earliest was in mid-May of 1985. It was noted that 1985 was an exceptionally strong year of recruitment, and 1987 turned out to be even stronger. If, as these results suggest, early appearances predict strong year- classes, then 1988 should be another strong year.

The other method being used by the Groundfish Communities Investigation to measure the strength of rockfish recruitment--occurrences of rockfish in the diet of king salmon--has not encountered exceptionally large numbers of young of the year this year (although this condition was also noted during the early phase of last year's strong recruitment). (E. Hobson, FTS 556- 0565)

GROUNDFISH ANALYSIS INVESTIGATION

Continued Evidence of Strong Year Class of Bocaccio

An article in the July-August 1986 Report of Activities presented evidence that the 1984 year class of bocaccio *(Sebastes paucispinis)* is relatively strong. Dr. William Lenarz, Chief of the Groundfish Analysis Investigation, reports that data collected from the fishery in 1986 continue to indicate that the 1984 year class is strong. Fish of the size mode of the 1984 year class were a major component of recreational catches in 1986 (Fig. 1). Almost all 1986 trawl landings of bocaccio in 1986 came from the 1984 year class.

There is speculation about whether the dominant size mode in the landings actually came from a pre-1984 year class because the fish from the 1984 year class were slightly larger than fish attributed to the very strong 1977 year class at the same age (Fig. 2). Also most species of rockfish do not grow as fast as bocaccio apparently do and the first annulus is difficult to interpret for bocaccio. David Woodbury, Biological Technician, estimated age in days of a bocaccio that was 15 cm in July 1984. He estimated that the fish was born in early December 1983 and found that what appeared to be daily rings were very easy to interpret. By convention, bocaccio born in December are considered members of the year class of the following year because the spawning season overlaps the calendar year. Woodbury also reports that several other species of rockfish

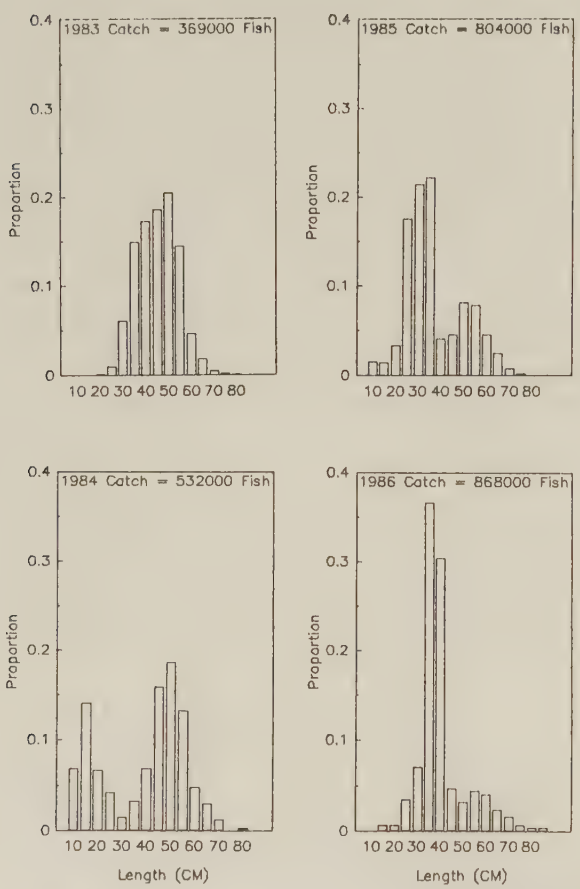


Figure 1. Length frequencies of recreationally caught bocaccio, 1983-1986. Source: Current Fishery Statistics, Numbers 8325, 8328, and 8393.

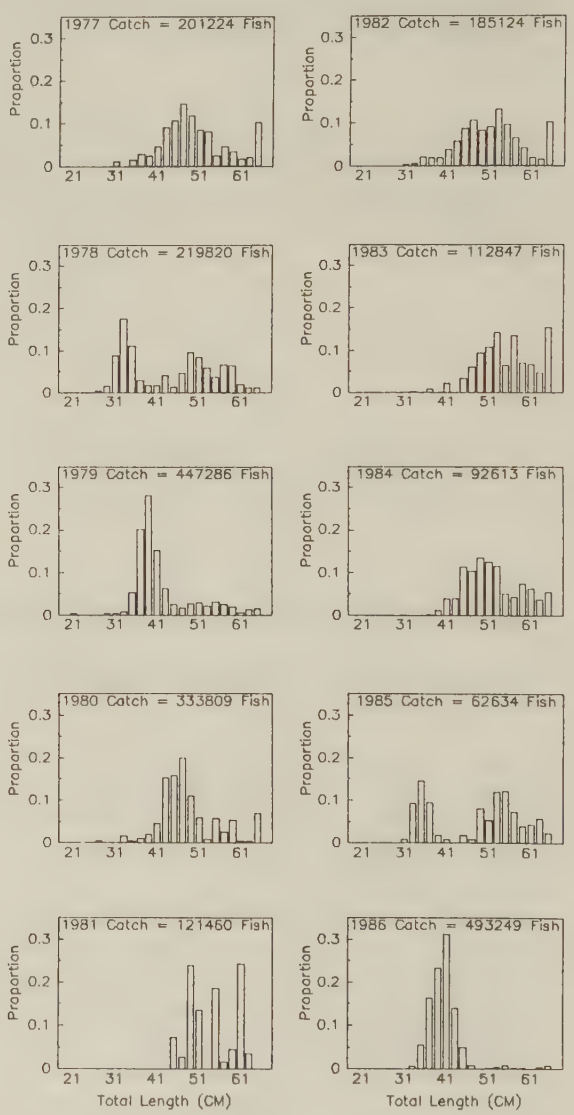


Figure 2. Length frequencies of trawl bocaccio landings in Monterey, 1977-1986. Source: California Department of Fish and Game and NMFS cooperative rockfish port-sampling program.

experienced relatively rapid growth as young of the year juveniles in 1984.

The relative abundance of the 1984 year class of bocaccio agrees with results of a rockfish recruitment survey off central California. The Groundfish Analysis Investigation has conducted midwater trawl surveys from the NOAA Ship *David Starr Jordan* to estimate the abundance of juvenile rockfish since 1983. The survey results indicate that juvenile bocaccio were more abundant in 1984 than any other year in the 1983-1987 period. The survey results also indicate that other important species of rockfish were only moderately abundant as juveniles in 1984. The other species are still too young to have recruited to the fisheries. (W. Lenarz, FTS 556-0565)

INFORMATION TECHNOLOGY SERVICES

$2 Million Committed for Information Technology in the 1990's

The National Marine Fisheries Service has committed $2 million in fiscal year 1989 for the Information Technology in the 1990's (IT-95) system. With this commitment, the National Data Management Committee can now proceed with the issuance of the Request for Comment, which is a draft document submitted to potential vendors for their comments on the clarity and completeness of the specifications for the IT-95 system proposed by the Committee. The Committee has been working for the past 2 years in developing requirements for a distributed top-end- computer, which would serve NMFS needs into the mid-1990's. During the first week of March, the Committee members, of which Dorothy Roll, as the Regional Data Base Administrator, is the representative for the Southwest Fisheries Center and the Southwest Region, met to finalize the specifications for the Request for Comment. The Request was released on March 21, and the vendors' suggestions will be reviewed and incorporated in the Request for Proposal, which is targeted to be issued to commercial vendors the end of June.

During the March meeting, representatives from the Federal Computer Performance Evaluation and Simulation Center (FEDSIM) a GSA branch, presented a strategy for developing a package of a benchmark mix of programs and operations, which will reflect the projected workload on the IT-95 system. This package must be completed for submission with the Request for Proposal. The FEDSIM representatives suggested that a benchmark committee be formed and a representative from each regional site serve on the committee. Roger Hewitt, NOAA Corps, has been designated the representative for the southwest regional area.

The benchmark committee will identify the key capabilities and functions that must be tested and write a script for the test programs. The committee will also serve as the technical evaluation board who will oversee the operations at all vendor sites.

In preparation for a meeting in Washington, D.C., Hewitt met with several staff members at the Center to identify the mix of programs that would reflect the southwest regional's projected load on the IT-95 system. Hewitt also contacted users at the Honolulu and Tiburon Laboratories and at the Pacific Fisheries Environmental Group for their input. The users are submitting descriptions of candidate programs to Hewitt for discussion at the benchmark committee meeting. (D. Roll, FTS 893-7057)

STATUS OF PUBLICATIONS

Published

Boehlert, G. W. 1988. Current-topography interactions at mid- ocean seamounts and the impact on pelagic ecosystems. GeoJournal 16.1:45-52.

Ocean currents impinging on topographic obstacles such as seamounts create a high level of variability in mesoscale physical oceanography. In the North Pacific, for example, the structure of the Kuroshio and its extension differ significantly E and W of the Emperor Seamount chain, and eddy fields detected downstream may be attributed to farfield seamount effects. Nearfield effects of seamounts have been theoretically predicted for several decades but only recently has theory been confirmed by observation. Taylor columns, quasi-stationary eddies over seamounts, alter flow patterns and thus have impacts on both benthos on seamounts and on the biota in water overlying the seamount.

SE Hancock Seamount, located at the N end of the Hawaiian Ridge (29°47'N; 179°04'E) has a summit depth of 265 m. This seamount is located near the subtropical front and is at the southerly extent of productive seamounts where trawl fisheries have existed in the past. The pelagic ecosystem in the upper 200 m over the seamount clearly differs from waters at control stations at distances of !O's of kilometers away as shown by plankton and midwater trawl hauls and hydroacoustic transects conducted during 1984 and 1985. Over the seamount, hydroacoustic transects show a significantly higher biomass of scatterers as compared to control stations. Sampling these scattering layers with small midwater trawls demonstrates high densities of a resident micronekton fauna dominated by the sternoptychid fish "*Maurolicus muelleri*" and the mysid "*Gnathophausia longispina*"; these taxa were virtually absent from the control stations, where oceanic micronekton, particularly larger forms, were generally in higher abundance than at the seamount stations. Similarly, ichthyoplankton abundance differs above the seamount and at reference stations. In summer sampling, larval fishes were less abundant over the seamount whereas in winter the abundance was greater there. The differences in distribution and abundance of both micronekton and ichthyoplankton are significant and consistently observed, suggesting that physical or biological processes at the seamount have important effects on the pelagic ecosystem. Hypotheses concerning current-topography interactions, exclusion of vertical migrators, and predation by resident micronekton and fishes can be used to explain the observed effects.

Seamounts and other areas of complex topography are frequently sites of highly productive ecosystems: the southern Emperor and northern Hawaiian Ridge seamounts provide a good example, with a catch of approximately one million tons of boarfish in ten years. The interaction of ocean currents and complex topography may play an important role in this high productivity, as demonstrated in the high biomass of lower trophic levels in the seamount ecosystem. Interannual variability in the latitudinal position of the subtropical front and the strength of current flow over these seamounts may result in significant differences in mesoscale physical oceanography and therefore in the productivity of these ecosystems.

Brill, R. W., R. Bourke, J. A. Brock, and M. D. Dailey. 1987. Prevalence and effects of infection of the dorsal aorta in yellowfin tuna, *Thunnus albacares*, by the larval cestode, *Dasyrhynchus talismani*. Fish. Bull., U.S. 85:767-776.

Approximately 60% of small (kg) yellowfin tuna, *Thunnus albacares*, caught near the Hawaiian Islands carry the plerocercoid (larval) stage of the cestode (tapeworm), *Dasyrhynchus talismani*, in their anterior dorsal aortas. Because the worms and the resultant host inflammation appear to occlude the vessel almost totally, we assumed that the parasite could increase natural mortality rates. Tuna could be limited in their ability to capture prey and therefore should show evidence of long- or short-term food deprivation. We measured body weight, fork length, liver weight, heart weight and, in fish captured from one school, RNA/DNA ratios (a measure of short-term growth rate), and otolith weight (a measure of long-term growth rate) from parasitized and unparasitized fish. We found no significant differences between infected and uninfected fish nor any evidence of starvation in infected fish. How small yellowfin tuna remain apparently unaffected by the parasitic occlusion of their dorsal aorta remains to be demonstrated.

We also examined changes in incidence of infection in small yellowfin tuna caught between February 1985 and March 1986 as well as the prevalence in large (45 kg) fish. Large yellowfin tuna were rarely parasitized (5.2%) in the dorsal aorta, but showed a high rate (80%) of infection within other major arteries. The prevalence in small fish varied dramatically with season, dropping suddenly from 66% in June-July 1985 to 11% in August-September 1985. Unparasitized fish caught during August-September 1985 showed significantly higher condition factors, relative heart weights, and relative liver weights than did unparasitized fish caught at other times of the year. We hypothesize that the sudden decrease in prevalence was due to influx of a

separate group of small yellowfin tuna into the Hawaiian fishery. We believe that this parasite may therefore serve as a marker for tracing the movements of small yellowfin tuna into and out of specific fisheries or areas.

Clarke, R. P., and S. G. Pooley. 1988. An economic analysis of lobster fishing vessel performance in the Northwestern Hawaiian Islands. U.S. Dep. Commer., NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-19-106, 46 p.

The economic and operational performance of three classes of lobster fishing vessels in the Northwestern Hawaiian Islands was examined. Operational information came from logbook catch and effort data required by law since the fishery came under Federal management in 1983. Economic information, with emphasis on cost-earnings data, was supplied by 12 vessels active during the 1985 and 1986 seasons. Only the Class II, midsized vessels were clearly profitable, whereas the larger Class I vessels faced a variety of cost constraints, and the Class III vessels faced a number of operational problems. Return on investment was estimated to be -4.0, 36.0, and -8.5% on Classes I-III, respectively. Sensitivity analysis indicated several factors can significantly affect net returns; however, the mid-1987 conditions in the fishery appeared to have had a balanced effect on vessel returns.

Eppley, Richard W., Elizabeth Stewart, Mark R. Abbot, and Robert W. Owen. 1987. Estimating ocean production from satellite-derived chlorophyll: insights from the Eastropac data set. Oceanol. Acta, Proceedings International Symposium on Equatorial Vertical Motion, Paris, 6-10 May 1985, 109-113.

The Eastropac expedition took place in 1967-1968 in the eastern tropical Pacific Ocean. Primary production was related to near-surface chlorophyll in these data. Much of the variability in the relation was due to the light-history of the phytoplankton and its photoadaptive state. This was due to changes in the depth of mixing of the surface waters more than changes in insolation. Accurate estimates of production from satellite chlorophyll measurements may require knowledge of the temporal and spatial variation in mixing of this region.

Forsyth, R. G., D. J. Alcorn, T. Gerrodette, and W. G. Gilmartin. 1988. The Hawaiian monk seal and green turtle on Pearl and Hermes Reef, 1986. U.S. Dep. Commer. , NOAA Tech. Memo. NOAA-TM-NMFS-SWFC-19-107, 24 p.

Hawaiian monk seal, *Monachus schauinslandi*, and green turtle, *Chelonia mydas*, research was conducted at Pearl and Hermes Reef in the Northwestern Hawaiian Islands, 3-9 June and 9-27 August 1986. Excluding pups, atoll counts of seals ranged from 37 to 54 ($x = 45.2$). Eighteen weaned pups were tagged. Two seals from Kure Atoll were sighted at Pearl and Hermes Reef in 1986. Twenty-three seal scats were collected. Twenty-three green turtles were tagged, and 15 green turtles previously tagged were resighted. Over 200 pieces of net and rope debris were sampled. No entanglements, injuries, or deaths were observed.

Moon, T. W., R. W. Brill, P. W. Hochachka, and J.-M. Weber. 1987. L-(+)-Lactate translocation into the red blood cells of the skipjack tuna (*Katsuwonus pelamis*). Can. J. Zool. 65:2570-2573.

Red blood cells from skipjack tuna, *Katsuwonus pelamis*, were incubated *in vitro* in various concentrations of L-(+)- lactate. There was no significant effect of pH between 6.6 and 8.1 on inward lactate translocation. Because there was a linear response between translocation rate and lactate added (up to 30 mm), we propose that a diffusive mechanism is the primary mode of lactate translocation into tuna red blood cells at least over the range of concentrations tested. This mechanism is unlike that reported for lactate influx in other animal cell types and may result from the reported differences in the control of proton movements across the red blood cell membrane of fish species.

Seckel, Gunter R. 1988. Indices for mid-latitude North Pacific winter wind systems; an exploratory investigation. GeoJournal 16.1:97-111.

Biological distributions and fish migrations during the spring and summer in the mid-latitude N Pacific are believed to be affected by the large-scale wind systems during the preceding winter. These wind systems are related to the field of atmospheric pressure which, on a monthly or quarterly time scale, show pronounced interannual variations. This exploratory investigation is concerned with measures of the large-scale wind systems that are indicative of their intensity, location, and size, and that can be derived from monthly or quarterly sea-level pressure distributions. Of interest are the NW, W, and SW wind systems which are related to the pressure gradients between the Siberian High and Aleutian Low, the Aleutian Low and the N Pacific Subtropical High, and the Aleutian Low and the N American High, respectively. Interannual changes in the winter sea-level pressure distribution pattern are primarily the result of changes in the pressure and zonal displacements of the Aleutian Low near 50°N. This property permitted simple derivation of wind indices from grid values of N hemisphere mean winter pressures distributions for the years 1947 to 1985. Indices, presented as normalized anomalies, are for the meridional component of the wind system at 50°N over the ocean W and E of the Aleutian Low, for the westerlies S of the Aleutian Low and for the longitude of this Low.

The paper concludes with a discussion of the limitations of the indices in terms of reflecting characteristic atmospheric pressure distribution patterns, an examination of the relationship between wind anomalies and El Niño events, and a discussion of the results in terms of oceanographic, climate, and biological implications.

Shomura, R. S. 1988. Cooperative fisheries oceanography cruise. Hawaii Fish. News 13(3):15.

Tagami, Darryl T. and Scott Barrows. 1988. Deep-sea shrimp trapping for *Heterocarpus laevigatus* in the Hawaiian Archipelago by a commercial fishing vessel. U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-103, 14 p.

The *Mokihana* was the most productive commercial fishing vessel in the offshore trap fishery for *Heterocarpus laevigatus* in Hawaii from 1983 to 1984. The *Mokihana* made 10 fishing trips from August 1983 to October 1984 and expended 208 days of fishing effort in the main Hawaiian Islands and the Northwestern Hawaiian Islands (NWHI) as far north as Gardner Pinnacles. Approximately 75 metric tons of whole *H. laevigatus* were landed in the fishing season, resulting in an overall catch per unit effort of 12.0 kg per trap-night. Mean catch rates for the main Hawaiian Islands (14.0 kg per trap-night) were higher than those for NWHI (9.3 kg per trap-night). The trap loss rate was an estimated 3.35%. The statistics presented in this report provide a fairly comprehensive geographic survey of the relative abundance of *H. laevigatus* in the Hawaiian Archipelago. They can be useful for stock assessment and fishery management purposes and can also serve as a guide to participants in the deep-sea shrimp fishery.

Thayer, Victoria G., Bruce G. McDonald, Julie M. Ellingson, Charles W. Oliver, David W. Behringer, and Stephen B. Reilly. 1988. Report of ecosystem studies conducted during the 1986 eastern tropical Pacific dolphin survey on the research vessel *McArthur.* U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-104, 6 p.

Thayer, Victoria G., Bruce G. McDonald, Julie M. Ellingson, Charles W. Oliver, David W. Behringer, and Stephen B. Reilly. 1988. Report of ecosystem studies conducted during the 1986 eastern tropical Pacific dolphin survey on the research vessel *David Starr Jordan.* U.S. Dep. Commer., NOAA Tech. Memo., NOAA-TM-NMFS-SWFC-105, 6 p.

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Polovina, Jeffrey J. A system of simultaneous dynamic production equations: Application to fishery forecasting in an island archipelago. Abstract for 1988 AFS Annual Meeting.

Ralston, S. and H. A. Williams. Numerical integration of daily growth increments: An efficient means of aging tropical fishes for stock assessment. For consideration for publication in the Canadian Journal of Fisheries and Aquatic Sciences.

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Smith, Paul E. and H. Geoffrey Moser. Fifty years of biological oceanography. For consideration for publication in California Cooperative Oceanic Fisheries Investigation Reports.

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Clarke, R. P., and A. C. Todoki. 1988. Comparison of three calculations of catch rates of the lobster fishery in the Northwestern Hawaiian Islands. SWFC Admin. Rep., Honolulu, H-88-6, 30 p.

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